X-Ray Sources for Studies of Ultrafast Processes Workshop

May 20, 2002

Many regions of the electromagnetic spectrum have provided critical information on the structure and dynamics of matter, but x-rays have been especially useful because their wavelengths are similar to atomic dimensions. So, x-rays have proven indispensable in determining the structure of materials at the atomic level.

In addition to a material's structure, scientists can also look at the dynamics of atoms inside the material. Over the past several decades, physicists have learned how to produce short pulses of light, which have provided valuable insights into the motions of various forms of matter, including biological systems. This workshop focused on the use of "X-ray Sources for Studies of Ultrafast Processes."

Lasers have played a key role in producing short pulses of visible, ultraviolet and infrared radiation. These pulses can last between a few billionths of a second (nanoseconds) to a few billionths of a billionth of a second (attoseconds). Using various combinations of laser and accelerator technologies, scientists are now on the verge of conducting studies of ultrafast processes at the atomic level using pulsed x-rays.

The most direct means of generating ultrashort pulses of x-rays is to focus a laser with a corresponding temporal structure onto a target, hence generating a plasma that emits a flash of x-rays. Chemist Christoph Rose-Petruck, of Brown University in Providence, Rhode Island, described such a system developed in his laboratory for the study of chemical processes. This system is relatively inexpensive, costing only about half a million dollars and offers all of the advantages of having a dedicated system.

Two speakers at the workshop described the generation of ultrafast X-ray pulses by Thompson scattering of a laser pulse off relativistic electrons generated by a linear accelerator. Physicist Gwyn Williams, of the Thomas Jefferson National Accelerator Facility (TJNAF) in Newport News, Virginia, described experiments performed at TJNAF's Free Electron Laser. BNL physicist Igor Pogorelsky described the generation of short X-ray pulses at BNL's Accelerator Test Facility.

Beyond the available or nearly available approaches outlined above, three speakers described accelerator based X-ray sources in various stages of development that offer the prospects of far greater brightness. Physicist John Arthur, of Stanford Linear Accelerator Facility (SLAC), described plans for SLAC's Sub-Picosecond Pulsed Source (SPPS), which will use that portion of the SLAC linac not required in the B-factory experiment.

The planned successor to the SPPS at SLAC is the Linac Coherent Light Source (LCLS), which was described by physicist Stephen Milton, of the Advanced

Workshop Speakers (from left): Christoph Rose-Petruck, (Brown University in Providence, Rhode Island), John Arthur, of Stanford Linear Accelerator Facility (SLAC), Stephen Milton, (Advanced Photon Source (APS) at Argonne National Laboratory), John Sutherland (BNL, Biology), Joel Brock, (Cornell University in Ithaca, New York), and Gwyn Williams (Thomas Jefferson National Laboratory).

Photon Source (APS) at Argonne National Laboratory. Development of the LCLS is being undertaken by a collaboration of six research organizations including SLAC, Argonne National Laboratory (ANL), BNL, Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LBNL), and the University of California at Los Angeles. It is designed to generate sub-picosecond pulsed X-rays using Self-Amplified Spontaneous Emission (SASE), hence eliminating the need for normal incidence mirrors to reflect the laser as used in conventional laser operating in the ultraviolet, visible and infrared regions of the spectrum or the use of seeded beams.

A parallel approach to generating ultrashort pulses of x-rays based on high energy pulsed electron beams generated in an Energy Recovering Linear (ERL) accelerator was described by physicist Joel Brock, of Cornell University in Ithaca, New York. Unlike the SPPS and LCLS, an ERL can function much in the fashion of existing synchrotron radiation sources supporting many experimental stations simultaneously, only some of which would be devoted to ultrafast timing.

The formal presentations were followed by a round table discussion on the present sources and future prospects for ultrafast X-rays. One point made by several of the discussants is that developments in accelerator physics have greatly outpaced development of detectors and beam transport optics. The scientists agreed that investment in needed in these areas to fully exploit current and future sources.

-John Sutherland